THE COLOURS OF FLOWERS, AS ILLUSTRATED BY THE BRITISH FLORA[1]

II.—*Further Examples of the General Law*

FLOWERS in which the carpels have arranged themselves in a circle around a common axis, like the *Geraniaceæ* and *Malvaceæ*, thereby show themselves to be more highly modified than flowers in which all the carpels are quite separate and scattered, like the simpler *Rosaceæ* and *Ranunculaceæ*. Still more do families such as the *Caryophyllaceæ*, in which all the five primitive carpels have completely coalesced into a single one-celled ovary. Accordingly, it is not remarkable that the pinks should never be yellow. On the other hand, this family has no very specialised members, like larkspur and monkshood, and therefore, it very rarely produces bluish or purplish flowers. Pinks, in fact, do not display so wide a range in either direction as *Ranunculaceæ*. They begin as high up as white, and hardly get any higher than red or carnation. Of their two sub-families, the *Alsineæ* have the sepals free, the blossoms widely expanded, and no special adaptations for insect fertilisation. They include all the small undeveloped field species, such as the chickweeds (*Stellaria media*, *Arenaria trinervis*, *Cerastium vulgatum*, &c.), stitchworts (*Stellaria holostea*, &c.), and cornspurries (*Spergula arvensis*), which have open flowers of a very primitive character; and almost all of them are white (Fig. 12). These are fertilised by miscellaneous small flies. The *Sileneæ*, on the other hand, including the campions and true pinks, have a tubular calyx, formed by the coalescence of the five sepals; and the expanded petals are raised on long claws, which makes their honey, inclosed in the tube, accessible only to the higher insects. Most of them also display special adaptations for a better class of insect fertilisation in the way of fringes or crowns on the petals. These more profoundly modified kinds are generally pink or red. For example, in the most advanced British genus, *Dianthus*, which has usually vandyked edges to the petals, our four English species are all brightly coloured; *D. armeria*, the Deptford pink, being red with dark spots, *D. prolifer* purplish red, *D. deltoides*, the maiden pink, rosy spotted with white, and *D. cæsius*, the Cheddar pink, bright rose-coloured (Fig. 13).

It is much the same with the allied genus *Lychnis*. Our own beautiful purple English corn-cockle (*L. githago*), is a highly developed campion, so specialised that only butterflies can reach its honey with their long tongues, as the nectaries are situated at the bottom of the tube. Two other species of campion, however, show us interestingly the way in which variations of colour may occur in a retrograde direction even among highly evolved forms. One of them, the day lychnis (*L. diurna*), has red, scentless flowers, opening in the morning, and it is chiefly fertilised by diurnal butterflies. But its descendant, the night lychnis (*L. vespertina*), has taken to fertilisation by means of moths; and as moths can only see white flowers it has become white, and has acquired a faint perfume as an extra attraction (Fig. 14). Still, the change has not yet become fully organised in the species, for one may often find a night lychnis at the present time which is only pale pink, instead of being pure white.

The *Cruciferæ* are a family which display a good deal of variety in colouration. The most primitive and simple forms have yellow flowers, as in the case of the cabbage genus (*Brassica*) including charlock, mustard, and turnip; the rockets (*Barbarea* and *Sisymbrium*); and the gold-of-pleasure (*Camelina sativa*). Most of these are dry-field weeds, and they have open little-developed blossoms. In the genus *Nasturtium* or watercress we have four species, three of which are yellow, while one is white. In treacle-mustard (*Erysimum*), the yellow is very pale, and the petals often become almost white. Just above these earliest forms come the common small white crucifers like *Cardamine hirsuta*, *Cochlearia officinalis*, and *Capsella bursa-pastoris*. Many of these are little if at all superior in organisation to the yellow species, and some of them (as we shall see hereafter) are evidently degenerate weeds of cultivation. But such flowers as *Alyssum maritimum*, with its sweet scent, its abundant honey, its reduced number of seeds, and its conspicuous, spreading milk-white petals, are certainly more developed than small yellow species like *Alyssum calycinum*. Even more remarkably is this the case in the genus *Iberis* or candytuft, which has become slightly irregular, by the two adjoining exterior petals growing larger than the interior ones. Accordingly, they are usually white, like our British species, *I. amara;* while some of the larger exotic species are a pretty pink in hue. The genus *Cardamine* supplies us with like instances. Here the smaller species have white flowers, and so has the large *C. amara*. But in *C. pratensis*, the cuckoo-flower, they are usually tinged with a pinkish purple, which often fades deep mauve; and in some showy exotic species the flowers are a rich pink. So with *Arabis;* our small English kinds are white; *A. petræa*, with larger petals, is often slightly purplish, and some handsome exotics are a vivid purple. In *Hesperis* we get a further degree of modification in that the petals are raised on rather long claws; and the flowers (represented in England by *H. matronalis*, the dame's-violet) are a fine purple, and possess a powerful perfume. Closely allied is the Virginia stock of our gardens (*Malcolmia*), which varies from pale pink to mauve. But the highest of all our crucifers are contained in the genera *Matthiola* and *Cheiranthus*, which have large spreading petals on long erect claws, besides often being sweet scented. The common stock (*M. incana*) is purple, reddish, or even violet; our other British species, *M. sinuata*, is pale lilac; and no member of the genus is ever yellow. The wall-flower (*Cheiranthus cheiri*) is rich orange or red, sometimes yellow: its colour, however, differs widely from the primitive yellow of the charlocks or buttercups; and it will receive further attention hereafter.

So much by way of illustration of the families with usually regular polypetalous flowers and free superior ovaries. We may next pass on to the families of polypetalous flowers with usually irregular corollas, which represent of course a higher stage of development in adaptation to insect visits. Of these, two good illustrative cases are included in the British flora. They are the *Polygalaceæ* and the *Violaceæ*.

Polygala vulgaris, or milkwort, our only British representative of the first named family, is an extremely irregular flower, very minutely and remarkably modified for special insect fertilisation. It is usually a bright blue in colour, but it often reverts to pink, and not infrequently even to white.

The *Violaceæ* or violets are a whole family of bilateral flowers, highly adapted to fertilisation by insects; and as a rule they are a deep blue in colour. This is the case with four of our British species, *Viola odorata*, *V. canina*, *V. hirta*, and *V. palustris*. Here too, however, white varieties easily arise by reversion; while one member of the group, the common pansy, *V. tricolor*, is perhaps the most variable flower in all nature. This case, again, will receive further attention when we come to consider the subject of variegation and of reversion or retrogression.

When we pass on to the *Corollifloræ*, in which the originally separate petals have coalesced into a single united tube, we meet with much more striking results. Here, where the very shape at once betokens high modification, yellow is a comparatively rare colour (especially as a ground-tone, though it often comes out in spots or patches), while purple and blue, so rare elsewhere, become almost the rule.

The family of *Campanulaceæ* forms an excellent ex-

[1] Continued from p. 304.

ample. Its flowers are usually blue or white, and the greater number of them, like the harebell (*Campanula rotundifolia*) and the Canterbury bell (*C. media*), are deep blue (Fig. 15). We have nine British species of the genus, varying from pale sky-blue to ultramarine and purplish cobalt, with an occasional relapse to white. Rampion and sheep's bit, also blue, are clustered heads of similar blossoms. The little blue lobelia of our borders, which is bilateral as well as tubular, belongs to a closely-related tribe. One of our British species, *Lobelia Dortmanna*,

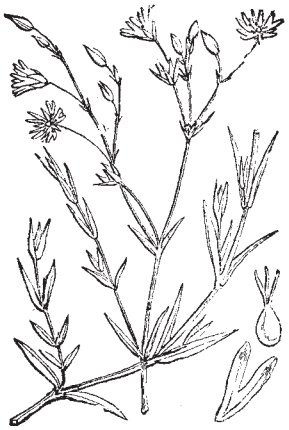

FIG. 12.—Lesser Stitchwort, white: type of simple open Alsineæ.

is sky-blue; the other, *L. urens*, is a dingy purple. Not far from them are the *Dipsaceæ*, including the lilac scabious, the blue devil's bit, and the mauve teasel. Amongst all these very highly-evolved groups blue distinctly forms the prevalent colour.

In the great family of the *Ericaceæ*, or heaths, which is highly adapted to insect fertilisation, more particularly by bees, purple and rose are the prevailing tints, so much so that, as we all have noticed a hundred times over, they often colour whole tracts of hillside together. The bell-shaped blossoms mark at once the position of the heaths

FIG. 13.—Dianthus, red spotted with darker tints: type of Sileneæ with tubular calyx.

with reference to insects; and the order, according to Mr. Bentham, supplies us with more ornamental plants than any other in the whole world. Among our British species, in the less developed forms, like *Vaccinium*, *Arbutus*, and *Andromeda*, the flowers are usually white, flesh-coloured, pinkish, or reddish. The highly developed *Ericæ*, on the other hand, are mostly purple or deep red. *E. vulgaris* has the calyx as well as the corolla coloured with a mauve variety of pink. *Menziesia cærulea* is a deep purplish blue. *Monotropa* alone, a very degraded leafless saprophyte form, has greenish yellow or pale brown free petals.

The *Boraginaceæ* are another very advanced family of *Corolliflorœ*, and they are blue almost without exception. They have usually highly-modified flowers, with a tube below and spreading lobes above; in addition to which most of the species possess remarkable and strongly-

FIG. 14.—Night Lychnis, white: adapted to fertilisation by moths.

developed appendages to the corolla, in the way of teeth, crowns, hairs, scales, parapets or valves. Of the common British species alone, the forget-me-nots (*Myosotis*) are clear sky-blue with a yellow eye; the viper's bugloss (*Echium vulgare*) is at first reddish-purple, and afterwards a deep blue; the lungwort (*Pulmonaria officinalis*) is also dark blue; and so are the two alkanets (*Anchusa*), the

FIG. 15.—Harebell, deep blue: type of Corollifloral blossoms.

true bugloss (*Lycopsis*), the madwort (*Asperugo*), and the familiar borage (*Borago officinalis*); though all of them by reversion occasionally produce purple or white flowers. Hounds-tongue (*Cynoglossum officinale*) is purple-red, and most of the other species vary between purple and blue; indeed, throughout the family most flowers are red at first and blue as they mature. Of these, borage at least is

habitually fertilised by bees, and the same is partially true of many of the other species. All of them are adapted to a high class of insect visitors.

Other families of regular *Corolliflorœ* must be glanced at more briefly. Among the *Gentianaceæ*, the less ad-

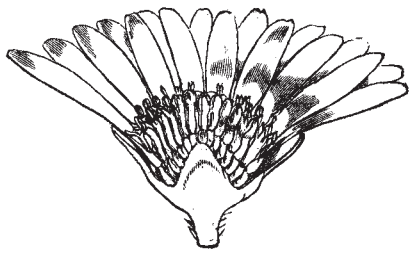

FIG. 16.—Section of Daisy; inner florets yellow; ray florets white, tipped with pink.

advanced types, like the simple *Chlora perfoliata* and *Limnanthemum nymphœoides*, are yellow, perhaps by reversion; but *Menyanthes trifoliata*, a slightly more developed ally of *Limnanthemum*, has white blossoms, tinged outside with red; *Erythrœa centaurium*, with a divided calyx and the cells of the ovary imperfectly

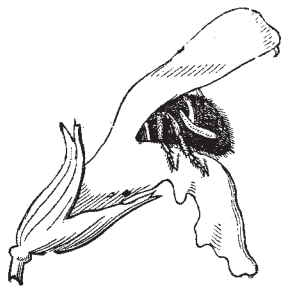

FIG. 17.—Flower of Sage, bright blue, visited by bee.

united, is pink; and the true gentians, *Gentiana verna*, *G. campestris*, *G. nivalis*, &c., with a tubular calyx, long throat, and sometimes fringed hairs to the tube, are bright blue. In *Apocynaceæ*, we have the highly developed periwinkles, *Vinca major* and *V. minor*, normally blue, though pink and white varieties or species are also culti-

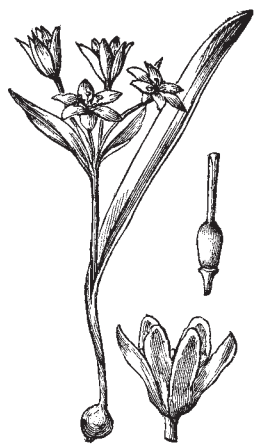

FIG. 18.—*Gagea lutea*, yellow: simplest type of lily.

vated. In *Plumbagineæ* we have the bluish purple sea-lavender (*Statice Limonium*) and the pink thrift (*Armeria vulgaris*). Other families with special peculiarities will receive notice later on.

It is necessary, however, here briefly to refer to the great family of *Compositæ*, some of whose peculiarities can only properly be considered when we come to inquire into the phenomena of relapse and retrogression. Nevertheless, even at the present stage they afford some excellent evidence. In certain ways they may be regarded as the very highest race of flowering plants. Not only are their petals united into a tubular corolla, but their blossoms are compounded into large groups of a very attractive sort. Each flower-head consists of a number of small florets, crowded so as to resemble a single

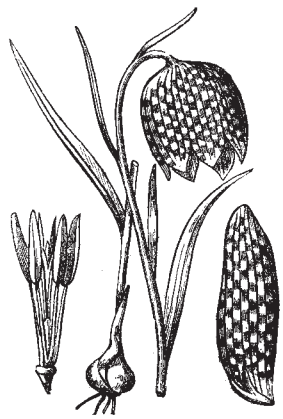

FIG. 19.—Fritillary, purple, spotted with white and red; developed type of lily.

blossom. So far as our present purpose is concerned, they fall naturally into three groups—Jussieu's old-fashioned sub-orders of *Ligulatæ*, *Cynaroideæ*, and *Corymbiferæ*, which are quite sufficient for all ordinary objects of botanical study.

We can only examine the last-named tribe at present, whose central florets, as a rule, are bright golden; a fact which shows pretty certainly that they are descended from a common ancestor who was also yellow. Moreover, these yellow florets are bell shaped. But the outer florets are generally sterile; and instead of being bell-shaped,

FIG. 20.—Spotted Orchid, purple with white patches: type of highly developed bilateral monocotyledons.

they form a long ray; while their corolla is at the same time much larger than that of the central blossoms. In short, they are sterilised members of the compound flower-head, specially set apart for the work of display; and thus they stand to the entire flower-head in the same relation as petals do to the simple original flower. Just as the petal is a specialised and sterilised stamen told off to do duty as an allurer of insects for the benefit of the whole flower, so the ray-floret is a specialised and sterilised blossom told off to do the self-same duty for the benefit of the composite flower-head.

Now, the earliest ray-florets would naturally be bright yellow, like the tubular blossoms of the central disk from which they sprang. And to this day the ray-florets of the simplest corymbiferous types, such as the corn-marigold (*Chrysanthemum segetum*), the sun-flower (*Helianthus annuus*), and the ragwort (*Senecio jacobæa*), are yellow, like the central flowers. In the camomile, however, the ox-eye daisy, and the may-weed (*Anthemis cotula*, *Chrysanthemum leucanthemum*, &c.), the rays have become white; and this, I think, fairly establishes the fact that white is a higher development of colour than yellow; for the change must surely have been made in order to attract special insects. In the true daisy, again (*Bellis perennis*), the white rays become tipped with pink, which sometimes rises almost to rose-colour (Fig. 16); and this stage is exactly analogous to that of apple-blossom, which similarly halts on the way from white petals to red. In our own asters (*A. tripolium*, &c.) and the Michaelmas daisies of America, we get a further advance to purple, lilac, and mauve, while both in these and in the chrysanthemums, true shades of blue not infrequently appear. The *Cinerarias* of our gardeners are similar forms of highly-developed groundsels from the Mediterranean and the Canary Islands.

Tubular flowers with an irregular corolla are obviously higher in their mode of adaptation to insect visits than tubular flowers of the ordinary symmetrical type. Amongst them, the first place must be assigned to the *Labiates*. Not only are they deeply tubular, but they are very bilateral and irregular indeed, displaying more modification of form than almost any other flowers except the orchids. They mostly secrete abundant honey, and often possess highly aromatic perfumes. Almost all of them are purple or blue. Among the best known English species are thyme, mint, marjoram, sage (Fig. 17), and basil, which it need hardly be said are great favourites with bees. Ground-ivy (*Nepeta glechoma*) is bright blue; catmint (*Nepeta cataria*), pale blue; *Prunella*, violet-purple; and common bugle (*Ajuga reptans*), blue or flesh colour. Many of the others are purple or purplish. It must be added that in this family the flowers are very liable to vary within the limit of the same species; and red, white, or purple specimens are not uncommon in many of the normally blue kinds.

The *Scrophularineæ*, and other allied irregular tubular families are mostly spotted, and so belong to a later stage of our inquiry; but even amongst this group, the *Veronica* genus has almost always pure blue flowers; foxglove (*Digitalis purpurea*) is purple; and many of the Broom-rapes (*Orobanchaceæ*) are more or less bluish. Blue and lilac also appear abundantly in spots or stripes in many species of *Linaria*, in *Euphrasia*, and in other genera.

We have given so much consideration to the Dicotyledons that the relatively simple and homogeneous Monocotyledons need not detain us long. Their coloration is as a whole both less complicated and less instructive.

The *Alismaceæ* answer very closely to the *Ranunculaceæ*, as being in all probability the earliest surviving type of entomophilous Monocotyledons. Their arrangement is of course trinary, but they have similarly separate carpels, often numerous, surrounded by one, two, three, or many rows of stamens, and then by one row of three petals and one row of three sepals. All our English species, however, are white or rosy, instead of yellow. As they are marsh plants, they seem to have reached or passed the stage of *Ranunculus aquatilis*. One species, *Alisma plantago*, the water-plantain, however, still retains a yellow claw to the petals, though the limb is white or pale pink. So also does *Damasonium stellatum*. These two interesting plants present a remarkable analogy to the water-crowfoot.

Among monocotyledonous families with a united ovary, the *Liliaceæ* are probably the most primitive. Their simplest type in England is *Gagea lutea* (Fig. 18), a yellow lily looking extremely like a bunch of *Ranunculus Ficaria*. In *Lloydia serotina*, a closely allied but more developed form, the petals are white, with a yellow base, and three reddish lines. The wild tulip is likewise yellow. *Allium ursinum*, a somewhat higher type, is pure white. The fritillary (*Fritillaria Meleagris*, Fig. 19), a large, handsome, bell-shaped flower, with separate petals converging into a campanulate form, and with a nectariferous cavity at their base, is purple or red, checquered with lurid marks; but it often reverts to white, or even to a faint yellow. In *Scilla*, however, including our common wild hyacinth (*S. nutans*), the deep tubular flowers, composed of perianth pieces with long claws, are usually blue, rarely pink or white; while in *Hyacinthus* and *Muscari*, which have a united bell-shaped or globular blossom, formed by the coalescence of the sepals and petals, dark-blue and ultramarine are the prevalent tones. Meadow saffron (*Colchicum autumnale*), which has also a united tube and very deep underground ovary, is a fine reddish purple: its stamens secrete honey.

The *Irideæ* and *Amaryllideæ* are more advanced than the lilies, in that they possess inferior ovaries—in other words, their perianth tube has coalesced with the walls of the inclosed carpels. In many cases, especially in the more highly-developed species, their flowers are red, blue, or purple. *Trichonema Bulbocodium* is purplish-blue, with a yellow centre. Our two native crocuses (*C. vernus* and *C. nudiflorus*) are also purple. *Sisyrinchium Bermudianum* is a delicate blue. *Gladiolus communis* is brilliant crimson. *Iris fœtidissima* is violet. Our own Amaryllids are white or primrose, but brilliant reds and purples, as well as highly-developed spotted types, are common amongst the cultivated exotics.

The *Orchidaceæ* stand at the head of the entomophilous Monocotyledons by virtue of their inferior ovary, their irregular flowers, and their extraordinary adaptations to insect fertilisation. Purples are the prevailing ground-tones (Fig. 20); but in the commonness of variegation and of specialised lines or spots of colour, the Orchids answer closely to the *Scrophularineæ* among Dicotyledons, and may therefore best be considered in a succeeding section.

GRANT ALLEN

(*To be continued.*)

ASTRONOMICAL OBSERVATORIES[1]

AMONG the contributions of public and private munificence to the advance of knowledge, none are more worthy of praise than those which have been devoted to astronomy. Among all the sciences, this is the one which is most completely dependent upon such contributions, because it has the least immediate application to the welfare of the individual. Happily, it is also the science of which the results are best adapted to strike the mind, and it has thus kept a position in public estimation which it could hardly have gained if it had depended for success solely upon its application to the practical problems of life. That the means which have been devoted to its prosecution have not always been expended in a manner which we now see would have been the best, is to be expected from the very nature of the case. Indeed, a large portion of the labour spent in any kind of scientific research is, in a certain sense, wasted, because the very knowledge which shows us how we might have done better has been gained through a long series of fruitless trials. But it is due both to ourselves and the patrons of astronomy that as soon as any knowledge bearing upon the question of the past application of money to the advance of science is obtained, use should be made of it to point out the mistakes of the past and the lessons for the future. It is now patent to all who have made a wide study of the subject that large amounts have been either wasted or applied in ways not the most effective in the erection and

[1] From the *North American Review*.